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The many dimensions of child poverty: Evidence from the UK Millennium Cohort Study

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ABSTRACT

In this paper we use a multidimensional framework to characterise child poverty in the UK. We examine the interdependencies amongst the different dimensions of multidimensional poverty, and the relationship between multidimensional poverty and income poverty. We also explore the links between multidimensional poverty, income poverty, and children's cognitive and non-cognitive development. Our findings suggest that multidimensional poverty identifies many but not all of the same children classified using standard income poverty measures. Approximately 20% of children are classified as poor on one measure but not the other. Children in workless households and ethnic minority children facing the highest odds of growing up in both multidimensional poverty and income poverty. We find similar levels of persistence in multidimensional poverty and income poverty, with 17% (18%) of children experiencing persistent multidimensional (income) poverty, and 10% of the children experiencing both persistent multidimensional poverty and persistent income poverty. Multidimensional poverty (both episodic and persistent) also has a detrimental impact on children's development over and above the negative impact of income poverty.

Keywords: multidimensional poverty; income poverty; persistent poverty; child development.

JEL classification codes: I32, J13, J62

1 Introduction and background

The policy landscape around child poverty in the UK has changed considerably in recent years. Explicit income-based poverty targets for the reduction in child poverty by 2020 were enshrined in law by the *Child Poverty Act 2010*.[1] This law was subsequently repealed by the *Welfare Reform and Work Act 2016*, and two new indicators of children's so-called 'life chances' were established – namely the proportion of children living in workless households, and children's educational attainment at age 16. It is evident that these new indicators are not measures of child poverty *per se*; rather they reflect current and future poverty *risks* rather than being a measure of current low living standards. It is against the background of this rapidly changing landscape that our paper examines the measurement and impact of child poverty. Specifically, we investigate the extent to which a broader multidimensional index of poverty identifies a similar or different subset of children as being in poverty than the standard income-based measures of poverty, and whether multidimensional poverty impacts upon children's cognitive and non-cognitive development over and above any effects of the more familiar income-based poverty measures.

It is useful to set out in more detail the several changes that have occurred in government policy and legislation regarding child poverty in order to provide the context and motivation for our paper. As noted above, the *Child Poverty Act 2010* established a commitment (based primarily around income-based poverty measures) to end child poverty in the UK by 2020 in recognition of the widespread consensus that the implications of living in poverty are much more severe and lasting for children than for adults (Notten and Roelen 2011a and 2011b). Children who grow up in poverty have poorer health and educational outcomes, both in the short-term and in the long-run (UNICEF 2012). Growing up in poverty puts children at risk

[1] There were 4 poverty targets in the *Child Poverty Act 2010*: (i) **Relative income poverty**: for less than 10% of children to live in households with relatively low income (equivalised net before housing cost (BHC) income below 60% of the UK median); (ii) **Absolute income poverty**: for less than 5% of children to live in households with absolute low income (equivalised net BHC income below 60% of real UK median in 2010/11); (iii) **Combined low income and material deprivation**: for less than 5% of children to live in material deprivation and low income (equivalised net BHC income below 70% of the UK median) households; and (iv) **Persistent poverty**: for less than 7% of children to live in relative income poverty for at least 3 of the last 4 years.

of permanent disadvantage, perpetuating an intergenerational cycle of disadvantage (Blanden et al 2007 and 2013).

In April 2011, the Government published its *Child Poverty Strategy* (DfE/DWP 2011) which re-iterated its commitment to reduce child poverty, but at the same time argued that income-based measures of poverty do not capture the full impact of poverty. In November 2012, DfE/DWP launched a consultation on *Measuring Child Poverty* (DWP 2012) with its aim to develop a "multidimensional measure of child poverty ... wider than income alone to reflect changes across a range of dimensions ... that taken together, will reflect the reality of growing up in poverty in the UK today." (p.15) Eight indicators were suggested for consideration: income and material deprivation; worklessness; unmanageable debt; poor housing; parental skill level; access to quality education; family stability; and parental health. These different indicators reflect not only current low living standards, but capture some of the causes of those low living standards, and also the potential risks of future low income. As noted by Browne et al (2013), it thus makes little sense to try to combine them all into a single multidimensional index.

Most recently, the *Welfare Reform and Work Act 2016* abandoned all of the income-based targets in the *Child Poverty Act 2010* (although maintained a commitment to continue to publish the different income poverty measures established in the *Child Poverty Act 2010*), and focuses instead on two indicators of 'life chances' - the number of children living in workless households and a measure of educational attainment at age 16. It is evident that these are not measures of child poverty. Moreover, they clearly identify a different set of children from more the conventional income-based poverty measures. For example, two-thirds of children classified as being in absolute income poverty under the *Child Poverty Act 2010* definition live in households where at least one adult is working - they are the children of the so-called 'working poor' (Belfield et al 2016). Thus they will be neglected by any initiatives targeted at workless households under the new *Welfare Reform and Work Act 2016*.

This recent policy debate on whether traditional income-based measures of poverty are really the best way of thinking about poverty, or whether the focus should be on what makes people poor, and what it means to be poor, is also reflected in the academic literature. It

has long been stressed by scholars that individuals' well-being is intrinsically multidimensional (e.g. Townsend 1979; Streeten 1981; Sen 1985) and there also now exists an increasing body of evidence in support of this view (e.g. Bradshaw et al 2007; Tomlinson et al 2008; Oroyemi et al 2009, Nolan and Whelan 2011). Consequently, societal measures of inequality and poverty should also reflect this multidimensionality. The poor themselves define their well-being and deprivation as multifaceted, with both monetary and non-monetary dimensions (such as life expectancy, literacy, housing quality etc.) regarded as important (Narayan et al 2000). A richer understanding of the impact and longer-term implications of poverty and deprivation can, therefore, only be gained from careful consideration of these multiple dimensions. Others have argued that, especially for households with low resources, indicators of consumption may provide a better measure of living standards than current income which is likely to be under-recorded (Brewer and O'Dea 2012). Belfield et al (2015) make a similar argument with regard to material deprivation. They suggest that looking only at current income can be insufficient when thinking about who is in 'poverty'. Some groups with similar incomes seem to be much more materially deprived than others.

Another key criticism of income-based measures of child poverty comes from the inherent assumption that higher household income is both necessary and sufficient for the provision of greater levels of material resources for children. However, differences over time and both within and between countries in such things as the provision of public goods, transfers (including subsidies for health and child care), housing costs, pre-school education provision, inter-temporal fluctuations in household savings and debt, and non-market attributes (Bourguiguon and Chakravarty 2003), mean that there is no simple relationship between contemporary household income and the resources available to a child (Ringen 1988). Further, income-based poverty measures, calculated from household income, ignore the intra-household distribution of resources (Ravallion 1996) and this becomes especially important when we consider children who have no command over the distribution of resources available to a household. There may be households which are not income-poor, but insufficient resources are allocated to the children, and thus the children could be 'deprived'.

Along with the acknowledgement that poverty – however measured – does matter for children's well-being and life chances, there is also increasing evidence that it is the persistence of poverty that matters even more (Barnes et al 2010; Schoon et al 2010 and 2012). In a recent paper (Dickerson and Popli 2016), we compared and contrasted the impact of being in relative poverty at any point in time with that of being *persistently* in poverty, in order to examine the cumulative impact of multiple and continuous periods of deprivation on the cognitive development of children. Our findings revealed that children born into poverty have significantly lower cognitive test scores, and that continually living in poverty in their early years in particular has a significant cumulative negative impact on their cognitive development.

The main aim of this paper is to bring together these two concepts – *multidimensional poverty* and *persistent poverty*. To our knowledge, there exists no previous study for the UK which combines these two concepts in a systematic and rigorous way as is undertaken here.[2] We are careful to select a range of dimensions of poverty and deprivation that all reflect current low living standards for children, and so can sensibly be combined into a single multidimensional poverty index. We document the distribution and evolution of these separate dimensions over time. We also explore their interdependencies and their relationship with the more conventional measure of income poverty. Income poverty, as usually defined in the UK, is a measure of relative poverty, and as such, it captures what is considered as a 'normal' or 'acceptable' standard of living in society. As incomes increase over time, what is 'normal' also changes and a relative income poverty measure will be able to capture this.[3] In contrast, a deprivation index, based on child-specific needs, captures the deprivation faced by children and is closer to being an absolute measure of poverty (although is time-specific); it captures the 'basic' living standard in terms of access to amenities and resources. While there will be a degree of overlap between relative and the absolute measures of poverty, it is entirely possible

[2]There are extant studies of multidimensional child poverty using data from developing and developed countries and we discuss these studies below. However, as far as we are aware, none rigorously examine the overlap between multidimensional poverty and income poverty, nor do any consider the persistence of multidimensional poverty.

[3]Of course, there are also absolute measures of income poverty which use a poverty line fixed in real terms over time. During the period of our data, income growth was slow and so the relative and absolute measures diverge very little. We can also define different poverty thresholds – e.g. at 50% or 70% of median income rather than 60% – but these are only very rarely utilised.

that children can be in relative income poverty but not absolutely deprived (and vice-versa). We examine the transitions (or dynamics) in multidimensional poverty and income poverty over time in order to see whether similar households/children are identified as being persistently in poverty. Finally we explore the relationship between multidimensional poverty and income poverty, and the cognitive and non-cognitive development of children.

2 Measurement of multidimensional poverty

We use existing definitions of multidimensional poverty (Bourguiguon and Chakravarty 2003; Atkinson 2003; Alkire and Foster 2011) to robustly measure multidimensional child poverty in the UK at a given point in time, and also its change over time.

Following Alkire and Foster (2011), let X be a $n \times D$ dimensional deprivation matrix, where x_{id} is the deprivation faced by child i $(i = 1, ..., n)$ in dimension d $(d = 1, ..., D)$. These dimensions can include social and economic deficiencies, as well as subjective and/or psychological indicators.[4] $x_{id} \in X$ is defined such that a higher value indicates higher levels of deprivation, where deprivations are represented by non-negative real numbers. For each dimension, a threshold, $\pi \equiv (\pi_1, \pi_2, ..., \pi_D)$, is defined such that a child is classified as deprived on that dimension if they are above the relevant threshold, i.e. if $x_{id} > \pi_d$. We next define a matrix g^0 which summarizes the deprivation status of all children across all dimensions in matrix X; where $g^0_{id} \in g^0$ is defined such that $g^0_{id} = 1$ whenever $x_{id} > \pi_d$ and $g^0_{id} = 0$ otherwise. The measure of deprivation in each dimension is then combined to calculate a weighted deprivation score, c_i, for every child in the sample as:

$$c_i = \sum_{d=1}^{D} w_d g^0_{id}; \quad 0 \leq c_i \leq D$$

where w_d is the weight attached to each dimension, such that $\sum_{d=1}^{D} w_d = D$.

From the deprivation score for each child, we can identify the multidimensionally poor, by

[4]Each dimension, d, can in turn be defined by multiple indicators. For example, if one of the dimensions of interest is 'housing quality', this can be defined by combining indicators on: the number of rooms available per person in the household, problems of condensation/damp, etc.

defining an indicator function, $MP_i^{(k)}$, such that $MP_i^{(k)} = I(c_i \geq k)$; where $0 < k \leq D$ is the poverty cutoff. The poverty cutoff k can be applied to the matrix g^0 to obtain a censored deprivation matrix, $g^0(k)$; where each element of $g^0(k)$ is defined as $g_{id}^0(k) = g_{id}^0 \times MP_i^{(k)}$. This can then be used to define the censored deprivation score for child i as:

$$c_i(k) = \sum_{d=1}^{D} w_d g_{id}^0(k); \quad 0 \leq c_i(k) \leq D$$

where $c_i(k) = c_i$ when $c_i \geq k$, and 0 otherwise.

From the individual deprivation scores, we can calculate the population average deprivation,

$$M_0 = \frac{1}{n} \sum_{i=1}^{n} c_i(k)$$

The population average deprivation score can also be written as $M_0 = H \times A$; where $H = q/n$ and $A = \sum_{i=1}^{n} c_i(k)/Dq$; where q is the total number of children who are multidimensional poor i.e. for whom $c_i(k) \neq 0$. H gives the incidence (head count ratio) of the multidimensional poor, and A gives the intensity of multidimensional poverty (amongst the poor). Alkire and Foster (2011) refer to M_0 as the 'adjusted headcount ratio'.

Any measure of multidimensional poverty is sensitive to the underlying choices made by the researchers (UNICEF 2012). These choices include: (i) the number and choice of dimensions (D); (ii) the weights (w_d) used to aggregate the dimensions to obtain the overall index; and (iii) the thresholds used both within a dimension (π_d) and the cutoff across dimensions (k) to define being in multidimensional poverty.

Consideration needs to be given first to what should or should not be included in the multidimensional measure. What is regarded as necessary/basic for children will depend on the aspirations and expectations both at the individual level and the societal level at any particular point in time. There have been numerous attempts in the literature to define the dimensions of poverty relevant to children. The choice of dimensions is, in most cases, driven by two factors. First, there are normative considerations: each dimension (and the indicator(s) used to define it) should reflect, in some way, the deprivations faced by the child in terms of

limiting their ability to experience what society values as a 'good life'. Second, there are issues of data availability: the choice of dimensions is limited to what is available at any point in time and also consistently available over time.

Gordon et al (2003) present the first rigorous attempt at measuring the extent and depth of multidimensional child poverty for developing countries. Their analysis covered all countries of Latin America and the Caribbean, South Asia, the Middle East and North Africa, Sub-Saharan Africa, East Asia and the Pacific. The dimensions of deprivation they considered were: food; safe drinking water; sanitation facilities; health; shelter; education; information; and access to services. These dimensions have largely been accepted as standard in the literature for developing countries (Roche 2013).

A number of studies have also focussed on European and other OECD countries (Bradshaw et al 2007; UNICEF 2007; OECD 2009; Richardson et al 2008; Nolan and Whelan 2011). Notten and Roelen (2010, 2011a and 2011b) use the 2007 EU-SILC data to examine multidimensional child poverty in Germany, France, Netherlands, and the UK. Their choice of domains is: housing conditions; neighbourhood conditions; access to basic services (health and education); and financial means. Our choice of dimensions (discussed in detail in the next section) is in line with the existing literature for European and OECD countries.

The relative importance given to different dimensions and indicators for each dimension is also a subjective judgement. The most common approach in the literature, which we follow here, is to use equal weights ($w_d = 1$). Justification for using equal weights comes from the ease of interpretation, as argued, for example, by Atkinson et al (2002) in their work on social indicators in Europe. As an alternative to equally weighting all dimensions, weights can be based on 'social norms' (with weights calculated as the proportion of households currently possessing the particular dimension), or generated as factor loadings with multidimensional poverty treated as a latent continuous factor (see the discussion in Decancq and Lugo 2013).

Finally, the thresholds for defining households in poverty or deprivation need to be delineated. Within a dimension, we set $\pi_d = 0$, such that any household deprived on one or more of the indicators is classified as deprived in that particular dimension. For the cutoff across

dimensions (k), we report M_0 for different values of k.

2.1 Dynamics of multidimensional poverty

Transition probabilities are used to capture the dynamics and persistence in both multidimensional poverty and income poverty (Apablaza and Yalonetzky 2011). Over any two periods, we can calculate four different transition probabilities $P_{i|j}$ where $P_{p|p}$ is the probability of being poor in period t, conditional on being poor in $t-s$ and $P_{np|p}$ is the probability of being non-poor in period t, conditional on being poor in $t-s$, such that $P_{p|p} + P_{np|p} = 1$. Similarly, $P_{p|np}$ is the probability of being poor in period t, conditional on being non-poor in $t-s$ and $P_{np|np}$ is the probability of being non-poor in period t, conditional on being non-poor in $t-s$, such that $P_{p|np} + P_{np|np} = 1$.

2.2 Subgroup decompositions

The index of multidimensional poverty, M_0, can be decomposed by population subgroups. Subgroup decompositions can reveal the inequities of distribution across society since different groups experience poverty differently. For example, we can examine lone parent households versus dual parent households, and calculate their relative contribution to the overall population index of multidimensional poverty. M_0 can also be decomposed by dimensions to identify the relative contribution of different dimensions to the overall index (for details see Alkire et al 2011).

We are not only interested in identifying the different subgroups of the population which contribute the most to overall M_0 but, from a policy perspective, it is also important to identify the households which are most *at risk* of poverty. The literature distinguishes between poverty and 'at-risk of being in poverty', with the latter often also referred to as 'vulnerability' (Ravallion 1988; Morduch 1994; Dutta et al 2011). Bane and Ellwood (1986) show that household formation decisions explain about 50% of the variation in the incidence of poverty in the US; these 'structural' factors are taken to indicate the risk of being in poverty. A more recent study by Worts et al (2010), using US and UK data, discusses the concentration of the various risk

factors, and their contribution to the persistence of poverty. The most commonly discussed risk factors in the literature are: lone parent household; long term unemployment; partners of the unemployed; young and the old; and race and ethnicity. In our analysis, we specifically explore worklessness, family stability (lone parent households), parental education, and ethnicity, and examine the impact of these different risk factors on the likelihood of a child growing up in multidimensional poverty.

3 Multidimensional poverty in MCS children

3.1 Data

To be able to combine the concepts of multidimensionality and persistence in child poverty we need a longitudinal data set that follows the same set of children from an early age, asking them similar, age-appropriate, questions at different points in time. This is clearly very demanding in terms of data requirements. We use the UK Millennium Cohort Study (MCS), which is following a large sample of around 19,000 children born in 2000-01. The sample covers all four countries of the UK, but families living in areas with a high ethnic minority population and/or with high deprivation were oversampled. The children were assessed, and their primary carer (in most cases mother/mother figure) interviewed, at five different points in time: when the children were 9 months old, 3 years old, 5 years old, 7 years old, and 11 years old. The father/father figure was also interviewed where present. The MCS collects information on a wide array of topics such as: family background; employment; income and poverty status of the household; housing conditions; neighbourhood; development of the children, etc. For further details on MCS see Hansen et al (2012).

To construct the multidimensional poverty index, we use two sweeps of the MCS: sweep two (MCS2) when the children were 3 years old and sweep four (MCS4) when they were 7 years old. MCS2 is the first sweep available where we have the relevant information for the dimensions of child poverty, and MCS4 is the last wave for which the dimensions chosen are

consistently available.[5] The core sample for the analysis undertaken here comprises of 12,548 children from 12,386 households – these are the children who are in both MCS2 and MCS4 and for whom we have complete information on all the dimensions. Refusing to participate is the biggest reason for sample attrition. The refusal rates are higher for the 'disadvantaged' and ethnic minority families, relative to 'advantaged' families, across all the four countries of the UK. Households which are more mobile are also more likely to be non-respondents (Plewis 2007). Ketende (2010) discusses in detail the response rates in MCS. In our analysis we use weights to account for both the differential sampling and the attrition/non-response bias; see Plewis (2007) for details on weights used in MCS.

Household income data (before housing costs) in the MCS is gathered using a banded response question, with different bands used for lone parent households and dual parent households. The MCS then imputes a continuous measure of income using interval regression techniques (Stewart 1983), with predictors including age, labour market status, region, benefit recipient, ethnicity, highest education level, housing tenure and number of children. The continuous income measure is then equivalised, using the OECD household equivalence scale (OECD 2009) to account for differences in household size and composition. The MCS equivalised income is then compared to the official poverty thresholds from the Households Below Average Income (HBAI 2010) series for the appropriate year of the MCS sweep. Thus the measure of child poverty utilised in our analysis is identical to the commonly employed definition of relative income poverty BHC for the UK, and is defined as living in a household with net equivalised income less than 60 percent of contemporaneous median UK household income. The incidence of income poverty in the MCS sample, however, has been consistently higher than the official HBAI estimates for children in poverty (Hansen et al 2010, chapter 12); one reason for this is that MCS is a sample of households with (at least one) young child, whereas the official HBAI estimates are for all dependent children (Bradshaw and Holmes 2010).

[5] The same questions are not asked in MCS5 (age 11), so we cannot construct the same dimensions. This is not surprising as many of the measures are age-specific. As a robustness check, we also undertook the analysis using MCS3 (age 5) and the results were not qualitatively different to those presented below.

3.2 Dimensions of multidimensional poverty

For deprivation beyond income poverty, we consider a number of dimensions which capture both the psychological (subjective) and material deprivations faced by children. The five dimensions considered in this paper are: financial constraints; material deprivation; parental involvement; housing environment; and neighbourhood. The indicators underlying each dimension are described in Table 1. Four of the five dimensions we use are in line with the existing literature on European and OECD countries, the only exception being parental involvement. We decided to include this dimension in light of the growing literature on early childhood development, which emphasizes the role of parental involvement (Heckman 2013). The indicators to capture this dimension are also determined by the extant literature – reading to the child, helping the child with their school work, and having a routine for the child (regular meal- and bed-times) are considered key parental investments.

These five dimensions and their constituent indicators reflect a range of deprivations which will affect a child's well-being and opportunities (the normative aspect, as explained above) and they are consistent with the literature cited above. Note that our choice of dimensions also covers three of the eight indicators listed in the government consultation on *Measuring Child Poverty* (i.e. income and material deprivation, unmanageable debt, and poor housing). The other five indicators (worklessness, parental skill level, access to quality education, family stability, and parental health) do not define children who are deprived *per se*, rather they indicate children who are 'at-risk-of being deprived'; we consider these separately below.

Table 2 presents the proportion of children classified as deprived on each of the indicators and five dimensions over the two MCS waves under consideration. The dimensions for which most children are classified as 'deprived' on the basis of the classification being used are Parental Involvement (PI) and Housing Environment (HE), for which more than 40% of all children are deprived.[6] The number of children deprived on different indicators and dimensions has

[6] One of the indicators within the HE dimension is 'housing tenure type', in which households are classified as deprived 'if living in: Local Authority, Housing Association, living with parents, or living rent free'. It could be argued that 'living with parents' and 'living rent free' are not necessarily negative outcomes. As a robustness check, we therefore redefined these households as not deprived (in MCS4, only about 2% of households are in these categories). This does not change the results qualitatively or quantitatively.

not changed significantly over time between MCS2 and MCS4, although of course it is not necessarily the same children who are deprived on each dimension in each sweep.

Table 3 presents the tetrachoric correlations[7] between the five different dimensions, both within and between waves. The top left quadrant of Table 3 shows the correlations between the different dimensions when the children are 3 years old. The highest correlation (0.61) is between financial constraints and material deprivation, and both of these dimensions are strongly correlated with poor housing environment. Parental involvement has the weakest relationship with the other dimensions. The pattern is similar in MCS4 as can be seen in the bottom right quadrant of Table 3.

The bottom left quadrant of Table 3 presents the relationship between the different dimensions over time. The diagonal correlations in this panel are all large in magnitude (with the exception of parental involvement), indicating a high degree of persistence in each dimension. The highest correlation is for the neighbourhood deprivation at age 3 and 7. The IMD index[8] is wave-specific so it allows for households to potentially be classified differently on neighbourhood deprivation from wave-to-wave, irrespective of whether they move or not. However, while residential mobility is high among the MCS households (with 40% of the households reporting at least one residential move between waves 1 and 2), the majority move into areas of similar neighbourhood deprivation. This is especially true of families living in the areas in the bottom three deciles of the IMD index (Kentende et al 2010). In our analysis sample, 94% of the households live in similarly classified neighbourhoods in both MCS2 and MCS4. This is also reflected in the high temporal correlation for poor housing environment.

The off-diagonal elements in the bottom left quadrant of Table 3 reveal that financial constraints, material deprivation and poor housing environment all have strong temporal relationships with the other dimensions. Taken together, these correlations reveal strong persistence within and between the multiple indicators of deprivation, with the exception of parental in-

[7] Tetrachoric correlations are calculated since all our dimensions are categorical (binary) variables.

[8] The IMD index is country specific: while the domains covered within the index for each country are similar, they are not identical. This index captures the neighbourhood socioeconomic disadvantage, which may have an impact on the outcomes of children over and above the impact of family-specific socioeconomic disadvantage (Chetty et al 2016).

volvement which seems to be fairly unrelated to these other indicators of poverty.

3.3 Measuring multidimensional poverty

Table 4 presents the multidimensional poverty index (M_0), the multidimensional headcount (H), and the intensity of multidimensional poverty (A) for different poverty cutoff values (k) as described in section 2. We also calculate the average deprivation (AD) as the mean number of dimensions of deprivation for those classified as being in poverty. As in Tables 2 and 3 above, within each dimension, we set $\pi_d = 0$, such that if a child is deprived on one indicator within a dimension, s/he is classified as deprived on that dimension; and we have assigned equal weights[9] to each dimension ($w_d = 1, \forall\ d$), such that $\sum w_d = 5$.

For $k = 1$, such that if a child is deprived on any one of the five dimensions they are classified as being in poverty, around ($H =$) 77% of children are classified as being in poverty in both MCS2 and MCS4. Using this threshold, on average, those in poverty are deprived on more than two dimensions. As the poverty cutoff, k, increases, the multidimensional headcount falls since fewer children will exceed the threshold and thus be categorised as being in poverty. At the extreme ($k = 5$), only 2-3% of children are deprived on all five dimensions.

There is little change in the calculated value of M_0 over time. If we take the poverty cutoff threshold to be $k = 3$ as highlighted in the table, then ($H =$) 28% (25%) of children are defined to be in multidimensional poverty in MCS2 (MCS4); and, on average, children who are classified as being in poverty according to this threshold are deprived on around ($AD =$) 3.5 of the five dimensions.

Results will be sensitive to the choice of cut-offs used within dimensions. One dimension where this might be of particular concern is the neighbourhood dimension. In this paper we have used the cut-off as the bottom two deciles of the IMD index. If we use just the bottom decile, then 10 percentage points fewer households are classified as poor on this dimension, whereas defining the cut-off as the bottom three deciles implies a 10 percentage point increase

[9] While the results reported in the paper use equal weights, as a robustness check, we also experimented with frequency weights ('social norms') and weights obtained from factor loadings (where multidimensional poverty is treated as a latent continuous variable); see Decancq and Lugo (2013) for details. Using different weights does not qualitatively or quantitatively change the results presented below (results available on request).

in the proportion of households classified as deprived. The impact of changing the cut-off on the multidimensional headcount is, however, much less: lowering the cut-off to the bottom decile decreases the headcount for MCS4 from ($H =$) 25% to 22% and increasing the cut-off to the bottom three deciles increases the headcount only to 28%.

As noted above, the multidimensional poverty measure M_0 can be decomposed by dimensions, so that the relative contribution of each dimension to the overall index can be identified. In MCS4, the most significant contribution to M_0 is the dimension capturing poor housing environment which accounts for one quarter of M_0. The smallest contribution is from neighbourhood, which accounts for one sixth of M_0, followed by financial constraints, parental investment and material deprivation which all contribute about one fifth. The contribution of the different dimensions to M_0 is similar for MCS2.

4 Multidimensional poverty and income poverty

In this section we examine the relationship between the individual dimensions of multidimensional poverty described in Section 3, as well as the aggregated M_0, and income poverty (IP), where IP is defined as households with income less than 60% of the contemporaneous median equivalised UK household income.

Table 5 presents the relationship between income poverty and the five dimensions of deprivation being considered; and the relationship between income poverty and multidimensional poverty, M_0. The first row of the table shows that income poverty ($IP = 1$) is 29% in MCS2 and 28% in MCS4. Each of the (2×2) cells in Table 5 then cross-classifies children in IP with poverty on each of the five dimensions of deprivation, while the last two rows cross-classify income poverty and overall multidimensional poverty. Thus, in MCS2, 63% of children are neither income poor nor financially constrained, although 12% of children are both. The largest overlap of income poverty is with poor housing environment; (22.8/29.0=) 79% of those who are income poor also have a poor housing environment in MCS2. Results for MCS4 are similar. Thus income poverty and a poor housing environment identify similar children. In contrast,

in both waves, fewer than half of those who are income poor live in deprived neighbourhoods or are financially constrained.

The off-diagonal elements in each (2×2) cell in Table 5 reveal those children who are differentially identified by low income and the different dimensions of deprivation as being in poverty. Clearly, while there is considerable overlap, on each dimension there are 20-30% of children who are classified as poor on either income or a dimension of deprivation, but not both, suggesting that the different dimensions are capturing rather different experiences of deprivation than low income alone would reflect.

Using a threshold of $k = 3$ (so that children are classified as multidimensionally poor if they are deprived in three or more of the five dimensions under consideration), the last two rows of Table 5 show the relationship between income poverty and multidimensional poverty. The findings for MCS2 and MCS4 are very similar. In both waves, 63% of children are neither multidimensionally poor nor income poor, while 18% (16%) of children are both multidimensionally poor and income poor in MCS2 (MCS4), respectively.[10] The off-diagonal entries reveal that around 11-12% of children are classified as income poor but not multidimensional poor, and 8-10% are multidimensionally poor but not income poor. Thus, while multidimensional poverty and income poverty identify many of the same children as being in poverty or not in poverty, even where they differ in their classification, this differential classification seems to be quite stable over time. A comparable 4-fold typology is constructed for households across all EU countries by Nolan and Whelan (2011) using the EU-SILC data. They also find a significant proportion of households which are only classified as poor on one but not both of the two poverty classifications, so this phenomenon is not limited just to the UK, nor to children only.

4.1 Multidimensional poverty and income poverty over time

Taking the multidimensional poverty threshold cutoff to be $k = 3$, Table 6 presents the transition probabilities for multidimensional poverty while Table 7 gives the transition probabili-

[10] Reducing the cut-off from $k = 3$ to $k = 2$ decreases the number of children classified as not poor on both measures, and increases the number of children classified as poor on both measures. For example, for MCS4, the proportion not-poor decreases from 63% to 50% and the proportion of poor children increases from 16% to 23%.

ties for income poverty. The degree of persistence in poverty over time is very high and is remarkably similar for the two measures of poverty. Around 64% of children who are multidimensionally poor at age 3 are still poor at age 7 (and 36% are not poor), the proportions are very similar for the traditional income poverty measure. Similarly, transitions rates into income and multidimensional poverty are very similar, with around 10% of those who are not multidimensionally (income) poor at age 3 moving into multidimensional (income) poverty by the age of 7.[11]

Table 8 examines the persistence of poverty across the two measures by combining the incidence of multidimensional poverty and of income poverty over time. 54% of children do not experience either multidimensional poverty or income poverty in either sweep of the data (i.e. 46% of children have at least some experience of poverty across the two waves). 18% have persistent income poverty, and 17% have persistent multidimensional poverty. Finally, 10% of children experience both persistent multidimensional poverty and persistent income poverty.[12]

The dimension within the multidimensional index which has the biggest persistence over time is neighbourhood deprivation (see Table 3). To gauge the impact that this dimension has on the overall persistence in the multidimensional index, we recalculated excluding the neighbourhood dimension. This reduces the overall multidimensional headcount in MCS4 from 25% to 18%. It also reduces the degree of persistence, with 10% of children now classified as being in persistent multidimensional poverty, and 6% of children now classified as being both persistently multidimensional poor and persistently income poor.

[11] Reducing the poverty threshold cut-off to $k = 2$ increases both the degree of persistence (to 75%) and transition probabilities into multidimensional poverty (to 20%); similarly increasing the cut-off reduces both the degree of persistence (to 41%) and the transition probabilities into multidimensional poverty (to 6%).

[12] Choice of k has an impact on the persistence of poverty across the two measures as well. Reducing the cut-off increases the proportion of children experiencing both persistent multidimensional poverty and persistent income poverty to 15% and increasing the cut-off decreases the proportion to 3%.

5 Decompositions and children at risk

5.1 Decompositions by subgroup

A primary advantage of the measure of multidimensional poverty adopted in our analysis is that it can also be decomposed across different population subgroups. Table 9, Panel A reports M_0 among single and dual parent/carer households in MCS4.[13] Similar to the incidence of income poverty which is also presented in the final column of Table 9, the incidence and intensity of multidimensional poverty is much higher amongst single parent households. In MCS4, 50% of children in single parent households are multidimensionally poor as compared to 19% in dual parent households. The corresponding figures for income poverty are 61% and 19% respectively. Thus, the incidence of multidimensional and income poverty is substantially greater amongst single parent households, with an incidence rate up to three times greater than for dual parent households on either measure.

Table 9, Panel B shows that Pakistani & Bangladeshi (P&B) and Black or Black British (BorBB) children have much higher incidences of both multidimensional and income poverty than other groups. However, the ranking of the relative incidence of multidimensional and income poverty is different between the two groups. While more than 70% of P&B children are in income poverty, as compared to 54% of BorBB children, the headcount measure of multidimensional poverty is comparatively lower for P&B children than for BorBB children (at 51% for P&B children as compared to 61% for BorBB children). Thus, it is clear that the relative incidence of multidimensional and income poverty can differ quite widely between groups.

Table 9, Panel C shows the subgroup decomposition by workless households. Not surprisingly, the incidence of both multidimensional and income poverty is significantly higher among workless households as compared to households which have at least one working adult. In the final panel (Panel D) of Table 9, we examine subgroups defined by mothers' education. The incidence of multidimensional poverty is four times greater among children with low edu-

[13] In both sections 5.1 and 5.2 we discuss decompositions from MCS4 only. Results for MCS2 are very similar and are available in the Appendix.

cated mothers relative to those with highly educated mothers, a similar gap to that for income poverty.

5.2 Children at risk of poverty

The subgroup characteristics identified in Table 9 - lone parents, ethnic groups, workless households and low mothers' education - are frequently used to identify children at risk of poverty. However, the membership of these subgroups often tends to be overlapping; for example, a child growing up in a single parent household is also more likely to be in a workless household (almost 50% of the single parent households in MCS4 are also workless households). Similarly, while 14% of the white households are workless households, the proportion is 37% for BorBB households and 25% for P&B households.

To identify the impact of belonging to a specific subgroup (e.g. lone parent) over and above the impact of being in another group (e.g. workless household) on the incidence of multidimensional poverty and income poverty, we estimate a set of logit regressions. The marginal risks for each characteristic are presented in the first two columns of Table 10. A child in a workless household has the highest relative odds of growing up in both multidimensional poverty and income poverty, *ceteris paribus*. Being in a single parent/carer household and having a mother with low education also significantly increase the odds of being in both multidimensional and income poverty. All ethnic minority children have significantly higher odds of being in multidimensional and income poverty, relative to white children (with the one exception of Indian children, for whom the odds of being in multidimensional poverty are no different from that of white children). BorBB children have the highest odds of growing up in multidimensional poverty relative to white children, while P&B children have the highest odds of growing up in income poverty. These findings are in line with the incidence of multidimensional and income poverty presented in Table 9.

To understand why some subgroups are more prone to multidimensional poverty relative to others we also estimate a set of logit regressions for the five separate dimensions of multidimensional poverty. These are reported in the last five columns of Table 10. The dependent

variable is the censored dimensional deprivation score, $g^0_{id}(k)$, for each of the five dimensions of multidimensional poverty. In general, children growing up in workless households face the highest relative risk of being deprived on most dimensions; however, children with low educated mothers face the highest odds of experiencing low parental involvement. BorBB children face the highest odds of living in both deprived neighbourhoods and poor housing environment; followed by the P&B children. Given that housing environment contributes the largest share to overall multidimensional poverty and these two minorities have the highest odds of being deprived on this dimension (and combined with the fact that the incidence of being a workless household is also very high among these two groups), it is unsurprising that they have the highest incidence of multidimensional poverty.

We also estimated logistic regressions for persistent multidimensional poverty and persistent income poverty, using the 'at-risk-factors' from MCS2 (results available on request). The findings from this analysis are similar to those in Table 10. Workless households are most likely to be in persistent multidimensional and income poverty; within ethnic minorities, BorBB children are most likely to be in persistent multidimensional poverty and P&B children are most likely to be in persistent income poverty.

6 Poverty and child development

It has long been established that income poverty is detrimental to the development of children (Brooks-Gunn and Duncan 1997; Duncan et al 2010). In this section, we explore the relationship between multidimensional poverty and children's development; specifically we examine if multidimensional poverty (both episodic and persistent) has an impact on child development over and above any impact of income poverty. We explore the impact of both episodic and persistent poverty.

Let child development at time t be defined as θ_t. θ_t is also often referred to in the literature as the (latent or observed) ability of the child. We are interested in the impact that multidimensional poverty and income poverty may have on θ_t. To understand this link, we specify a

dynamic model of child development (adapted from Cunha and Heckman 2008), such that:

$$\theta_t^k = \gamma_{1t}^k \theta_{t-1}^k + \gamma_{2t}^k IP_t + \gamma_{3t}^k MP_t + \gamma_{4t}^k X_t + \eta_t^k, \qquad t = 1, 2 \tag{1}$$

where θ_t^k is the vector of child ability at time t, with $k = C, N$ such that θ_t^C is the cognitive development of the child and θ_t^N captures the non-cognitive abilities of the child; we consider two time periods, $t = 1$ when the children are 3 years old, and $t = 2$ when the children are 7 years old. Development (ability) is assumed to be dynamic in nature and, at any point in time, depends on: past ability θ_{t-1}^k; income poverty, IP_t; multidimensional poverty, MP_t; and a set of control variables, X_t, that can affect ability formation such as the socioeconomic status of the parents. γ_{jt}^k, $j = 1, \ldots, 4$ are time-varying parameters to be estimated; and η_t^k is the normal error term, assumed to be independent across individuals and over time.

One of the important explanatory variables in the model of child development is parental investment. We do not include this explicitly in our model as parental involvement is subsumed in our measure of multidimensional poverty. For period $t = 1$ (age 3) there are no specific measures to identify the initial endowments of ability, θ_0. We instead assume that initial endowments depend in a linear fashion on a set of covariates, X_0; data for these covariates comes from MCS1 when the children were 9 months old and includes variables capturing the family circumstances at the birth of the child, such as birthweigth and mother's age.[14] For further details on model estimation and identification, see Dickerson and Popli (2016).

We are particularly interested in the impact of MP_t over and above that of IP_t. Equation (1) gives us the impact of contemporaneous episodes of (multidimensional and income) poverty on child development; however, it still (indirectly) allows for the effects of previous episodes of poverty via lagged ability, θ_{t-1}. We can (and do) extend the model to directly include the past episodes of poverty to capture the impact of *persistent* poverty on children.

[14] For $t = 1, 2$ the two equations we want to estimate are:
$\theta_1^k = \gamma_{11}^k \theta_0^k + \gamma_{21}^k IP_1 + \gamma_{31}^k MP_1 + \gamma_{41}^k X_1 + \eta_1^k$ for $t = 1$
$\theta_2^k = \gamma_{12}^k \theta_1^k + \gamma_{22}^k IP_2 + \gamma_{32}^k MP_2 + \gamma_{42}^k X_2 + \eta_2^k$ for $t = 2$
where θ_1^k is child's ability at age 3 and θ_2^k is child's ability at age 7. To estimate the equation for $t = 1$ we need θ_0^k (initial endowments), as we do not have data on this we proxy it by a set of covariates X_0, such that $\theta_0 = f(X_0)$, and we assume this to be a linear function. The estimated equation for $t = 1$ therefore is: $\theta_1^k = \gamma_{11}^k X_0 + \gamma_{21}^k IP_1 + \gamma_{31}^k MP_1 + \gamma_{41}^k X_1 + \eta_1^k$. The equations are estimated simultaneously.

In our analysis we assume that cognitive abilities are latent, and are measured with error. The MCS records a number of standard tests of cognitive development, at ages 3 (MCS2) and 7 (MCS4) years; these are age-appropriate tests administered to the children themselves; see Connelly (2013) for information on tests available in the MCS. These tests can be used as measures which have informational content for the latent variables of interest and, rather than an ad-hoc combination of test scores, we use a factor model to estimate the latent cognitive ability. Specifically, in MCS2, children were assessed on two tests: the British Ability Scales (BAS) Naming Vocabulary test which is a verbal scale which assesses spoken vocabulary; and the Bracken School Readiness Assessment (BSRA) which is used to assess the conceptual development of young children across a wide range of categories (colours; letters; numbers/counting; sizes; comparisons; and shapes). In MCS4 children were assessed on three tests: the BAS Pattern Construction test where the child constructs a design by putting together flat squares or solid cubes with black and yellow patterns on each side; the BAS Word Reading test in which the child reads aloud a series of words presented on a card; and the Progress in Maths test in which a range of tasks covering number, shape, space, measures and data are assessed.

The non-cognitive development of children is assessed in the MCS using the Strength and Difficulty Questionnaire (SDQ), which is filled out by the mother of the child, at both age 3 and age 7.[15] SDQ is a well-established instrument used to identify childhood behavioural problems in community settings (Goodman 1997). It has a set of 25 questions assessing the child on five different dimensions, with five questions on each factor: emotional problems; conduct problems; hyperactivity; peer problems; and pro-social behaviour. All 25 questions can be answered as: 'certainly true' (score 2), 'somewhat true' (score 1), and 'not true' (score 0). Four of the five domains in SDQ (other than pro-social behaviour) are combined to compute the total difficulty

[15] At age 7, MCS has data on teacher-reported SDQ as well, and thus we experimented with using this measure instead of mother-reported SDQ. There are two potential concerns to note. First, we lose more than 2,000 observations from our sample since the overall response rate for teacher-reported SDQ is only 63%. Second, we are estimating a dynamic model where past SDQ influences current SDQ. At age 3, we have only mother-reported SDQ. Changing the reporter by taking teacher-reported SDQ at age 7 thus introduces a further degree of error. The key findings with respect to the poverty dummies however remain qualitatively the same. The only major change is that the estimated persistence in SDQ falls, i.e. the coefficient for SDQ at age 3 in the equation for age 7 is only half as large as when using mother-reported SDQ only. This is not surprising given the change in the person reporting the child's SDQ.

score (ranging from 0 to 40) for the child; where a higher score indicates greater behavioural problems. For our analysis, we reverse the scale of SDQ such that a higher score indicates better behaviour and thus higher non-cognitive ability.

In vector X_0 which captures the initial conditions, we use: birth weight; ethnicity of the child; whether or not the child is first-born; mother's education and mother's age at the birth of the child. All these variables are used to capture any early (dis)advantage. Better educated and older mothers are often able to provide a better developmental environment for their children (Todd and Wolpin 2007, Guryan et al 2008); birthweight is used as proxy for genetic endowments (Del Bono et al 2012); and a dummy for first-born is used to capture the birth order effects given that first-born children are found to outperform their younger siblings (Black et al 2005). Ethnicity is used to capture children at risk of poverty. The other control variables (X_t) are: a binary indicator for gender of the child; binary indicators for workless households and single parent households (these two variables capture children at risk of poverty); age of the child in months[16]; and the number of siblings in the household.

In Table 11 we report the impact of contemporaneous multidimensional poverty and income poverty on the cognitive and non-cognitive development of children.[17] The four equations across the two time periods (see footnote 14) are estimated jointly and simultaneously (see Muthén and Satorra, 1995 for details). At age 3, multidimensional poverty has a significant and a negative impact on both the cognitive and non-cognitive development of children, over and above the negative impact of income poverty; the impact is much stronger for non-cognitive (social and behavioural) development than for cognitive development (test scores).

A child who faces only multidimensional poverty can be expected to be 0.305 standard deviations (SDs) (equivalently 8 percentile ranks) below the latent cognitive ability score of a child who does not face multidimensional poverty.[18] Similarly, a child who faces only income

[16] The test scores for cognitive ability are age standardized, but only within a three month range. Thus to allow for any further variations by age, we control for age in months for both cogntive and non-cognitive development.

[17] We lose some observations when utilising MCS1 (age 9 months) for the initial conditions. As a robustness check, all the analysis presented in Table 1 to Table 10 was repeated for the sample used here. The results, which are available on request from the authors, are qualitatively and quantitatively unaffected.

[18] The percentile rank changes are calculated by multiplying the observed changes in the latent variable by the SD of the underlying measures. See Dickerson and Popli (2016) for details.

poverty can be expected to be 0.244 SDs (equivalently 7 percentile ranks) below a child who is not in an income poor household. A child who faces both multidimensional and income poverty can therefore be expected to be about 15 percentile ranks below the child who has no experience of poverty – this completely eliminates the positive impact of having a highly educated mother. By age 7, the impact of both multidimensional and income poverty is insignificant for cognitive development, but both continue to remain significantly negative for children's non-cognitive development.

In Table 12 we report the impact of persistent income poverty and persistent multidimensional poverty on the cognitive and non-cognitive development of children.[19] Contemporaneous and lagged poverty status (multidimensional and income) have no impact on cognitive development of children at age 7. This is consistent with the findings of Dickerson and Popli (2016) where we find that by the time the children are 7 years old, the direct impact of income poverty is not significant for cognitive development. This however does not mean that poverty does not have an indirect impact. Given the evidence of self-productivity in cognitive development (and the coefficient of 0.647 on lagged cognitive development), any impact on age 3 cognitive development will have an indirect impact on age 7 cognitive ability. One explanation of these results could be that by the time children are age 7, they are in formal schooling and some of the adverse impacts of home environment are being compensated. However, the results for non-cognitive development - which mainly depends on the home environment of the children - show a continued negative and significant impact of multidimensional poverty. In particular, and over and above the impact of lagged non-cognitive development, persistent multidimensional poverty has a large negative influence on children's non-cognitive development. Being in persistent multidimensional poverty has an impact of ((–0.074) + (–0.142) =) –0.216, which is almost three times greater than just being in multidimensional poverty today but not in the previous period (–0.074). Persistent multidimensional poverty therefore appears to be particularly detrimental for children's non-cognitive development.

[19]Note that the estimates presented in columns 1 and 2 ($t = 1$) of Table 12 differ slightly from those in Table 11. This is because all 4 columns are estimated jointly, and the addition of lagged poverty in columns 3 and 4 ($t = 2$) has a small impact on the point estimates in columns 1 and 2 through their impact on the variance-covariance matrix of the estimates.

7 Conclusions

In this paper, we construct a measure of multidimensional poverty from the MCS data for children age 3 and age 7, and compare and contrast this to a conventional relative income based measure of poverty. Our results suggest that, while our measure of multidimensional poverty overlaps with the income poverty measure, there are 20% of children who are classified as poor on one measure but not the other. When we examine the different dimensions, there is a significant overlap between income poverty and poor housing environment, and poor housing environment accounts for a quarter of the multidimensional poverty.

We also consider children 'at risk of poverty' i.e. children growing up in lone parent households and workless households, ethnic minority children and children with low-educated mothers. Overall our findings suggest that while the incidence of both multidimensional and income poverty affects similar groups of children, there are important and significant differences in the relative incidence between groups and between the two measures of poverty. Children in workless households face the highest odds of growing up in both income and multidimensional poverty; and Black or Black British and Pakistani and Bangladeshi children have the highest likelihood of growing up in poor housing environments and deprived neighbourhoods.

We find similar levels of persistence in multidimensional poverty and income poverty; with 17% (18%) of children experiencing persistent multidimensional (income) poverty, and 10% of the children experiencing both persistent multidimensional poverty and income poverty. Poverty (episodic and persistent) has a negative impact on child development, with multidimensional poverty having a negative impact on the development of children over and above the negative impact of income poverty. While the direct effects of poverty (income and multidimensional) seem to diminish over time for cognitive development, they remain significantly detrimental for non-cognitive development.

Using relative household income as the measure of poverty has the key advantage of simplicity. Income is easily understood as a measure, and it is more readily available than any multidimensional index of poverty. Any multidimensional measure of poverty is necessarily more complex since it involves aggregating over a range of different (and subjectively selected)

dimensions. There are also greater data requirements, especially if the intention is to measure multidimensional poverty consistently over time. However, it is clear that this appeal to simplicity as a justification for continuing to define poverty by a relative household income threshold alone is misplaced in the case of measuring and assessing the deprivation faced by children. Income poverty fails to adequately record the extent, persistence and degree to which children experience deprivation, perhaps in part because children have no control over the allocation of resources within the household. As shown in this paper, in order to assess deprivation amongst children, and the impact of that deprivation on children's cognitive and non-cognitive development, income poverty alone is insufficient – it needs to be supplemented by a consistent and rigorous multidimensional measure in order to identify all children experiencing poverty.

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Table 1: Dimensions of deprivation

Dimension:	Indicators:	Description:
D1: Financial Constraints (FC)	1. Managing financially	Mothers asked: 'How well managing financially?' If either *finding it **quite** difficult* or *finding it **very** difficult*, then defined as NOT managing well financially.
	2. Behind with bills	Mothers asked if 'behind with bills'. There are 11 categories including: behind with electricity bill, behind with telephone bill, behind with loan repayments etc. If the respondent says yes to **any**, then the household is classified as 'behind with bills'.
D2: Material Deprivation (MD)	1. Whether child has weatherproof coat 2. Whether child has all-weather shoes* 3. Has annual holiday not staying with relatives	In MCS2, two questions are asked; first is 'Yes' or 'No'; those who say 'No' are then asked a further question with the options: 'We would like to have this, but cannot', and 'We do not want/need this at the moment'. In MCS4, for each of the three indicators, the mother could give one of three answers: 'We already have this', 'We would like to have this, but cannot', and 'We do not want/need this at the moment'. All who answered: 'We would like to have this, but cannot' are classified as deprived.
D3: Parental Involvement (PI)	1. How often read to the child	Classified as deprived on this indicator if no one reads to the child or the frequency of reading to child is once or twice a month or less.
	2. How often help child with: alphabet (at age 3), reading (at age 7)	Classified as deprived on this indicator if: Never/Occasionally/less than once a week (age 3); Never/Once or twice a month/Less often (age 7)
	3. Does the child have regular bedtime	Classified as deprived on this indicator if: never or almost never; sometimes.
	4. Meal time: Does the child have regular mealtime (age 3)	Classified as deprived on this indicator if: never or almost never; sometimes.
	Who eats with child regularly (age 7)	Classified as deprived on this indicator is the child does not eat with Parent(s) and/or other children (brothers and sisters) in the family.
D4: Housing Environment (HE)	1. Housing tenure type	Classified as deprived on this indicator if living in: Local Authority, housing association, living with parents, or living rent free.
	2. Overcrowding	Divide the total number of household members (people) by the number of rooms in the house (other than bathrooms/toilets/halls); House is considered overcrowded if people/rooms > 1.
	3. Problems with condensation/damp	Deprived if having a problem with damp.
	4. Child exposed to smoking	Mother is asked: 'Does anyone smoke near the child?'
D5: Neighbourhood (NH)	1. Index of Multiple Deprivation (IMD)	The IMD in the local area is constructed separately across the four countries of UK. MCS reports the distribution of deciles of this index. Household classified as deprived on this dimension if is in the bottom two deciles.

Notes to Table 1:

1. All the indicators are classified to capture deprivation.
2. * In MCS2, the question is 'whether child has new properly fitted shoes'.

Table 2: Proportion of children deprived on different dimensions

Dimension:	Indicators:	MCS2 (%)	MCS4 (%)
D1: Financial Constraints (FC)	*1. Managing financially*	*10.4*	*12.7*
	2. Behind with bills	*15.6*	*15.3*
	% Deprived on FC	20.9	21.9
D2: Material Deprivation (MD)	*1. Weatherproof coat*	*0.6*	*0.9*
	2. All-weather shoes	*1.0*	*2.5*
	3. Annual holiday	*28.7*	*29.6*
	% Deprived on MD	28.9	30.2
D3: Parental Involvement (PI)	*1. Read to the child*	*7.3*	*10.1*
	2. Help child with alphabet/reading	*31.3*	*34.9*
	3. Regular bedtime	*20.4*	*8.7*
	4. Regular meal time	*9.2*	*2.9*
	% Deprived on PI	49.8	45.8
D4: Housing Environment (HE)	*1. Housing tenure type*	*28.3*	*25.6*
	2. Overcrowding	*8.8*	*9.3*
	3. Problems with condensation/damp	*14.7*	*14.6*
	4. Child exposed to smoking	*17.9*	*13.2*
	% Deprived on HE	45.3	42.1
D5: Neighbourhood (NH)	*1. Deprived neighbourhood*	*22.3*	*20.8*
	% Deprived on NH	22.3	20.8
Income Poverty (IP)	Income poor (<60% median hh income)	29.0	27.5

Notes to Table 2:

1. We take $\pi_d = 0$, i.e. any household deprived on one or more indicators is classified as deprived in that particular dimension.
2. Income Poverty (IP) is defined as household income less than 60% of median equivalised UK household income.
3. Sample size N = 12,548 except for income poverty. For income poverty in MCS2: N = 10,755 for MCS4: N = 12,544.
4. Sample weights correcting for sample design and non-response bias have been used.

Table 3: Correlation matrix between the different dimensions

		MCS2 (Age 3)					MCS4 (Age 7)			
		FC	**MD**	**PI**	**HE**	**NH**	**FC**	**MD**	**PI**	**HE**
MCS2 (Age 3)	**MD**	0.61*								
	PI	0.13*	0.15*							
	HE	0.52*	0.55*	0.19*						
	NH	0.32*	0.41*	0.17*	0.55*					
MCS4 (Age 7)	**FC**	0.55*	0.48*	0.13*	0.45*	0.28*				
	MD	0.47*	0.66*	0.15*	0.50*	0.40*	0.61*			
	PI	0.03	0.02	0.12*	0.01	-0.01	0.01	0.01		
	HE	0.49*	0.55*	0.18*	0.80*	0.52*	0.46*	0.52*	0.01	
	NH	0.33*	0.42*	0.17*	0.54*	0.97*	0.27*	0.41*	-0.01	0.55*

Notes to Table 3:

1. Dimensions are: FC: Financial Constraints; MD: Material Deprivation; PI: Parental Involvement; HE: Housing Environment; and NH: Neighbourhood.
2. Sample size: N = 12,548
3. * denotes tetrachoric correlation is significant at the 1% significance level.

Table 4: Multidimensional Poverty Index (M_0)

	MCS2 (Age 3)				MCS4 (Age 7)			
Poverty cut-off (*k*):	***M_0 =HA***	***H***	***A***	***AD***	***M_0 =HA***	***H***	***A***	***AD***
1	0.334	0.767	0.436	2.180	0.321	0.775	0.415	2.075
2	0.275	0.469	0.585	2.929	0.258	0.455	0.567	2.829
3	0.198	0.275	0.720	3.587	0.178	0.254	0.699	3.485
4	0.108	0.127	0.857	4.274	0.085	0.101	0.846	4.223
5	0.035	0.035	1.000	5.000	0.023	0.023	1.000	5.000

Notes to Table 4:

1. Here we use $w_d = 1$, such that $\Sigma w_d = 5$; N = 12,548.
2. *H* = Multidimensional headcount; *A* = Intensity of deprivation; *AD* = average deprivation among the poor. See text for details
3. Sample weights correcting for sample design and non-response bias have been used.

Table 5: Relationship between income poverty, different dimensions and overall $MP_i^{(k)}$ (k = 3)

	MCS2 (Age 3) %		MCS4 (Age 7) %	
	IP = 0	IP = 1	IP = 0	IP = 1
Dimension	71.0	29.0	72.5	27.5
FC = 0	62.6	16.5	62.5	15.6
FC > 0	8.5	12.5	9.9	11.9
MD = 0	59.7	11.9	58.5	11.3
MD > 0	11.3	17.1	14.0	16.2
PI = 0	38.9	12.2	39.1	15.1
PI > 0	32.1	16.8	33.3	12.5
HE = 0	49.6	6.2	51.3	6.6
HE > 0	21.4	22.8	21.2	21.0
NH = 0	62.8	16.3	63.7	15.5
NH > 0	8.2	12.7	8.8	12.1
Overall				
$MP = 0$	62.9	11.0	62.9	11.7
$MP = 1$	8.4	18.0	9.6	15.9

Notes to Table 5:

1. IP: Income Poverty; FC: Financial Constraints; MD: Material Deprivation; PI: Parental Involvement; HE: Housing Environment; and NH: Neighbourhood.
2. Sample sizes are MCS2: N = 10,755; and MCS4: N = 12,544.
3. The figures within each 2×2 sub-matrix may not add to 100% due to rounding.
4. Sample weights correcting for sample design and non-response bias have been used.

Table 6: Transition probabilities for Multidimensional Poverty (*k* =3)

		MCS2 (Age 3)	
		Multidimensionally poor (MP = 1)	Multidimensionally not-poor (MP = 0)
MCS4 (Age 7)	Multidimensionally poor (MP = 1)	$P_{p\|p}$ = 0.641	$P_{p\|np}$ = 0.108
	Multidimensionally not-poor (MP = 0)	$P_{np\|p}$ = 0.359	$P_{np\|np}$ = 0.892

Notes to Table 6:

1. Here we use $w_d = 1$, such that $\Sigma w_d = 5$; N = 12,548.
2. Sample weights correcting for sample design and non-response bias have been used.

Table 7: Transition probabilities for Income Poverty

		MCS2 (Age 3)	
		Income poor (IP = 1)	Income not-poor (IP = 0)
MCS4 (Age 7)	Income poor (IP = 1)	$P_{p\|p}$ = 0.624	$P_{p\|np}$ = 0.103
	Income not-poor (IP = 0)	$P_{np\|p}$ = 0.376	$P_{np\|np}$ = 0.900

Notes to Table 7:

1. N = 10,754.
2. Sample weights correcting for sample design and non-response bias have been used.

Table 8: Multidimensional Poverty (*k* = 3) and Income Poverty over time

		MP incidence over time (%)			
		never poor	*poor in 1 wave*	*poor in both*	Total
Income Poverty over time (%)	*never poor*	54.5	6.5	2.7	63.7
	poor in 1 wave	8.3	5.3	4.7	18.2
	poor in both	3.1	5.2	9.7	18.1
	Total	66.0	17.0	17.0	100

Notes to Table 8:

1. N = 10,754.
2. Sample weights correcting for sample design and non-response bias have been used.

Table 9: Subgroup Decomposition, M_0 (k = 3) and IP: MCS4

	%	$M_0 = HA$	H	A	AD	% IP
Panel A: Single and dual parent/carer households						
Single parent/carer household	21.4	0.358	0.503	0.712	3.539	60.5
Dual parent/carer household	78.6	0.129	0.187	0.691	3.445	18.6
Panel B: Ethnicity						
White	86.3	0.154	0.222	0.692	3.462	23.7
Mixed	3.2	0.277	0.388	0.715	3.517	39.6
Indian	1.9	0.129	0.188	0.686	3.392	24.5
Pakistani and Bangladeshi	4.4	0.365	0.506	0.722	3.569	72.6
Black or Black British	2.9	0.441	0.607	0.726	3.620	54.2
Other	1.3	0.342	0.493	0.695	3.501	48.9
Panel C: Workless Households						
No working adult (workless)	15.9	0.495	0.677	0.731	3.628	87.5
At least one working adult	84.2	0.118	0.175	0.678	3.381	16.3
Panel D: Mothers' Education						
High education (NQF 4+)	32.5	0.056	0.085	0.664	3.320	7.5
Low education	67.5	0.236	0.336	0.704	3.504	37.1

Notes to Table 9:

1. Here we use $w_d = 1$, such that $\Sigma w_d = 5$.
2. *H* = Multidimensional headcount; *A* = Intensity of deprivation; *AD* = average deprivation among the poor. See text for details.
3. Sample weights correcting for sample design and non-response bias have been used.

Table 10: Risk of Multidimensional Poverty and Income Poverty: odds-ratio (MCS4)

	Dependent Variables		Dependent Variable: censored dimensional deprivation score				
Independent Variables:	***MP***	***IP***	***FC***	***MD***	***PI***	***HE***	***NH***
Mother low education	3.92***	4.97***	2.98***	3.80***	3.00***	4.34***	4.24***
Workless household	5.34***	19.75***	3.67***	5.26***	2.82***	5.58***	4.03***
Single parent/carer	1.98***	2.86***	1.87***	1.83***	1.63***	1.85***	1.46***
Ethnicity (base=White)							
Mixed	1.77***	1.50**	1.54**	1.56***	1.50**	1.82***	1.57**
Indian	1.02	1.64**	1.18	1.07	0.92	0.73	1.17
P&B	3.30***	11.37***	1.58***	3.15***	2.08***	2.60***	5.48***
BorBB	5.38***	3.24***	2.69***	4.05***	1.86***	5.78***	6.33***
Other	3.89***	4.15***	2.80***	3.72***	2.73***	2.98***	2.59***
N	12,512	12,510	12,512	12,512	12,512	12,512	12,512

Notes to Table 10:

1. *** p<0.01, ** p<0.05, * p<0.10; Sample weights have been used in the analysis.
2. Base: white child in a dual parent/carer household, where at least one adult works, and mother has high education.

Table 11: Cognitive and non-cognitive development and the incidence of multidimensional and income poverty

	MCS2 (Age 3)		MCS4 (Age 7)	
	Latent cognitive development	Non-cognitive development	Latent cognitive development	Non-cognitive development
	θ_1		θ_2	
θ_{t-1}	-	-	0.652***	0.525***
MP_t	-0.305***	-0.431***	-0.026	-0.142***
IP_t	-0.244***	-0.076**	-0.064	-0.100***
Control variables (X_t)				
Girl	0.342***	0.220***	-0.146***	0.151***
Age in months	0.061***	0.024**	0.062***	0.025***
Number of siblings	-0.119***	-0.009	0.039***	-0.006
Workless household	-0.190***	-0.191***	-0.082*	-0.086**
Single parent/carer	-0.029	0.013	-0.074**	-0.046
Initial conditions (X_0)				
Birth weight	0.097***	0.054***	-	-
First born	0.276***	0.005	-	-
Mother high education	0.380***	0.229***	-	-
Mother's age	0.146***	0.123***	-	-
Ethnicity				
Mixed	-0.051	0.001	-	-
Indian	-0.392***	-0.271***	-	-
P&B	-0.783***	-0.254***	-	-
BorBB	-0.443***	0.146**	-	-
Other	-0.386***	0.059	-	-

Notes to Table 11:

1. All the reported coefficients are standardized. For the continuous independent variables, the coefficient represents the change in the dependent variable associated with a one standard deviation (SD) change in the independent variable. For the binary independent variables, the coefficient represents the change associated with a shift in the variable from 0 to 1.
2. Sample size: 10,198; CFI = 0.881; RMSE = 0.039.
3. *** p<0.01, ** p<0.05, * p<0.10; Sample weights have been used in the analysis.

Table 12: Cognitive and non-cognitive development and the *persistence* of multidimensional and income poverty

	MCS2 (Age 3)		MCS4 (Age 7)	
	Latent cognitive development	Non-cognitive development	Latent cognitive development	Non-cognitive development
	θ_1		θ_2	
θ_{t-1}	-	-	0.647***	0.512***
MP_t	-0.304***	-0.428***	-0.017	-0.074**
IP_t	-0.238***	-0.075**	-0.032	-0.055
MP_{t-1}	-		-0.013	-0.142***
IP_{t-1}	-		-0.032	-0.066**
Control variables (X_t)				
Girl	0.341***	0.220***	-0.143***	0.154***
Age in months	0.061***	0.024**	0.062***	0.027***
Number of siblings	-0.119***	-0.009	0.040***	0.012
Workless household	-0.191***	-0.192***	-0.077	-0.062
Single parent/carer	-0.029	-0.014	-0.071*	-0.033
Initial conditions (X_0)				
Birth weight	0.097***	0.054***	-	-
First born	0.276***	0.004	-	-
Mother high education	0.380***	0.229***	-	-
Mother's age	0.146***	0.123***	-	-
Ethnicity				
Mixed	-0.051	-0.001	-	-
Indian	-0.392***	-0.268***	-	-
P&B	-0.785***	-0.252***	-	-
BorBB	-0.443***	0.147**	-	-
Other	-0.386***	-0.060	-	-

Notes to Table 12:

1. All the reported coefficients are standardized. For the continuous independent variables, the coefficient represents the change in the dependent variable associated with a one standard deviation (SD) change in the independent variable. For the binary independent variables, the coefficient represents the change associated with a shift in the variable from 0 to 1.
2. Sample size: 10,198; CFI = 0.883; RMSE = 0.039.
3. *** p<0.01, ** p<0.05, * p<0.10; Sample weights have been used in the analysis.

Appendix

Table A1: Subgroup Decomposition, M_0 (k = 3) and IP for MCS2

	%	$M_0 = HA$	H	A	AD	% IP
Panel A: Single and dual parent/carer households						
Single parent/carer household	17.6	0.441	0.596	0.740	3.657	72.9
Dual parent/carer household	82.4	0.146	0.206	0.709	3.544	19.6
Panel B: Ethnicity						
White	86.3	0.169	0.238	0.711	3.558	26.1
Mixed	3.2	0.298	0.417	0.714	3.497	45.4
Indian	1.9	0.183	0.260	0.702	3.445	25.9
Pakistani and Bangladeshi	4.4	0.428	0.579	0.739	3.658	70.7
Black or Black British	2.9	0.504	0.654	0.771	3.865	54.5
Other	1.3	0.342	0.466	0.735	3.713	44.3
Panel C: Workless Households						
No working adult (workless)	17.5	0.549	0.728	0.754	3.720	90.9
At least one working adult	85.5	0.123	0.178	0.693	3.472	16.3
Panel D: Mothers' Education						
High education (NQF 4+)	32.5	0.059	0.084	0.697	3.474	10.1
Low education	67.5	0.264	0.366	0.723	3.600	38.7

Notes to Table A1:

1. Here we use $w_d = 1$, such that $\Sigma w_d = 5$.
2. H = Multidimensional headcount; A = Intensity of deprivation; AD = average deprivation among the poor. See text for details.
3. Sample weights correcting for sample design and non-response bias have been used.

Table A2: Risk of Multidimensional Poverty and Income Poverty: odds-ratio (MCS2)

	Dependent Variables		**Dependent Variable: censored dimensional deprivation score**				
Independent Variables:	***MP***	***IP***	***FC***	***MD***	***PI***	***HE***	***NH***
Mother low education	4.73***	4.03***	3.38***	4.10***	4.19***	4.94***	4.26***
Workless household	6.98***	26.43***	4.61***	5.88***	4.03***	7.09***	4.79***
Single parent/carer	1.64***	2.66***	1.40***	1.68***	1.32***	1.58***	1.22**
Ethnicity (base=White)							
Mixed	1.73***	1.72***	1.58**	1.53**	1.28	1.55***	1.39*
Indian	1.47**	1.65**	1.29	1.59**	1.51**	1.04	1.40*
P&B	3.92***	8.97***	1.31**	2.91***	3.26***	2.71***	6.63***
BorBB	5.74***	1.92***	2.34***	4.27***	3.36***	5.57***	6.67***
Other	3.03***	2.78***	2.47***	2.91***	2.74***	2.46***	2.30***
N	12,471	10,719	12,471	12,471	12,471	12,471	12,471

Notes to Table A2:

1. *** p<0.01, ** p<0.05, * p<0.10; Sample weights have been used in the analysis.
2. Base: white child in a dual parent/carer household, where at least one adult works, and mother has high education.